Organic Chemistry
10.2 – Alkanes

IB Chemistry

Topic 10 – Organic

Source:

Brown, Ford, Talbot

10.2 Alkanes - 2 hours

- 10.2.1 Explain the low reactivity of alkanes in terms of bond enthalpies and bond polarity. (3)
- 10.2.2 Describe, using equations, the complete and incomplete combustion of alkanes. (2)
- 10.2.3 Describe, using equations, the reactions of methane and ethane with chlorine and bromine. (2)
- 10.2.4 Explain the reactions of methane and ethane with chlorine and bromine in terms of a free-radical mechanism. (3)

Alkanes

10.2.1 Explain the low reactivity of alkanes in terms of bond enthalpies and bond polarity. (3)

- Alkanes contain only C-C and C-H bonds and are both strong so only react in the presence of a strong source of energy
  - C-C, 348 kJ/mol
  - C-H, 412 kJ/mol
  - Can be stored, transported, and compressed safely which is why they are so useful
  - C-H, C-C bonds are characteristically non-polar so are not susceptible to attack by most common reactants.

Alkanes as Fuels

10.2.2 Describe, using equations, the complete and incomplete combustion of alkanes. (2)

- Release significant amounts of energy when they burn, highly exothermic, because large amount of energy released when forming..
  - Double bonds of CO_2
  - Bonds in H_2O

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \quad \Delta H = -2200$ kJ/mol

However, when O_2 is limited.....

$2C_3H_8 + 7O_2 \rightarrow 6CO + 8H_2O$

when O_2 is extremely limited.....

$C_3H_8 + 2O_2 \rightarrow 3C + 4H_2O$

These are examples of the incomplete combustion of fossil fuels which makes them an environmental concern

Halogenation of Alkanes

10.2.3 Describe, using equations, the reactions of methane and ethane with chlorine and bromine. (2)

- Saturated compounds, the main type of reaction they can undergo is **substitution**
- Occurs when another reactant (Halogen), take the place of a hydrogen atom in the alkane
- For example, methane CH_4, reacts with chlorine Cl_2 producing chloromethane and hydrogen chloride
- Cannot take place in the dark, as the UV light is necessary to break the covalent bond.
- Splits chlorine, Cl_2, into **free radicals** and the chain reaction begins...

Bond Breaking

Types of Bond Breaking (bond fission)	
Homolytic fission	**Heterolytic fission**
•When a covalent bond breaks by splitting the shared pair of electrons between the two products •Produces two free radicals each with an unpaired electron	•When a covalent bond breaks which both the shared electrons going to one of the products •Produces two oppositely charged ions

Halogenation of Alkanes

10.2.4 Explain the reactions of methane and ethane with chlorine and bromine in terms of a free-radical mechanism. (3)

UV light

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

Part I - Initiation:

Homolytic Fission because the bond between the two Chlorine atoms is broken, splitting the shared pair of electrons between two atoms. Homo- means "the same" and refers to the fact that the two products have equal assignment of electrons from the bond.

$Cl_2 \rightarrow 2Cl\bullet$ radicals

Halogenation of Alkanes

UV light

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

Part II - Propagation:

Called such because they both use and produce free radicals, and so allow the reaction to continue. This is why the reaction is often called a chain reaction.

$$Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$$

$$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$$

$$CH_3Cl + Cl\bullet \rightarrow CH_2Cl\bullet + HCl$$

$$CH_2Cl\bullet + Cl_2 \rightarrow CH_2Cl_2 + Cl\bullet$$

Halogenation of Alkanes

UV light

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

Part III - Termination:

These reactions move free radicals from the mixture by causing them to react together and pair up electrons.

$$Cl\bullet + Cl\bullet \rightarrow Cl_2$$

$$CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$$

$$CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$$